PHYSICAL OCEANOGRAPHIC STUDIES OF NARRAGANSETT BAY, 1957 and 1958

SPECIAL SCIENTIFIC REPORT–FISHERIES No. 457

UNITED STATES DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE

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by

Steacy D. Hicks

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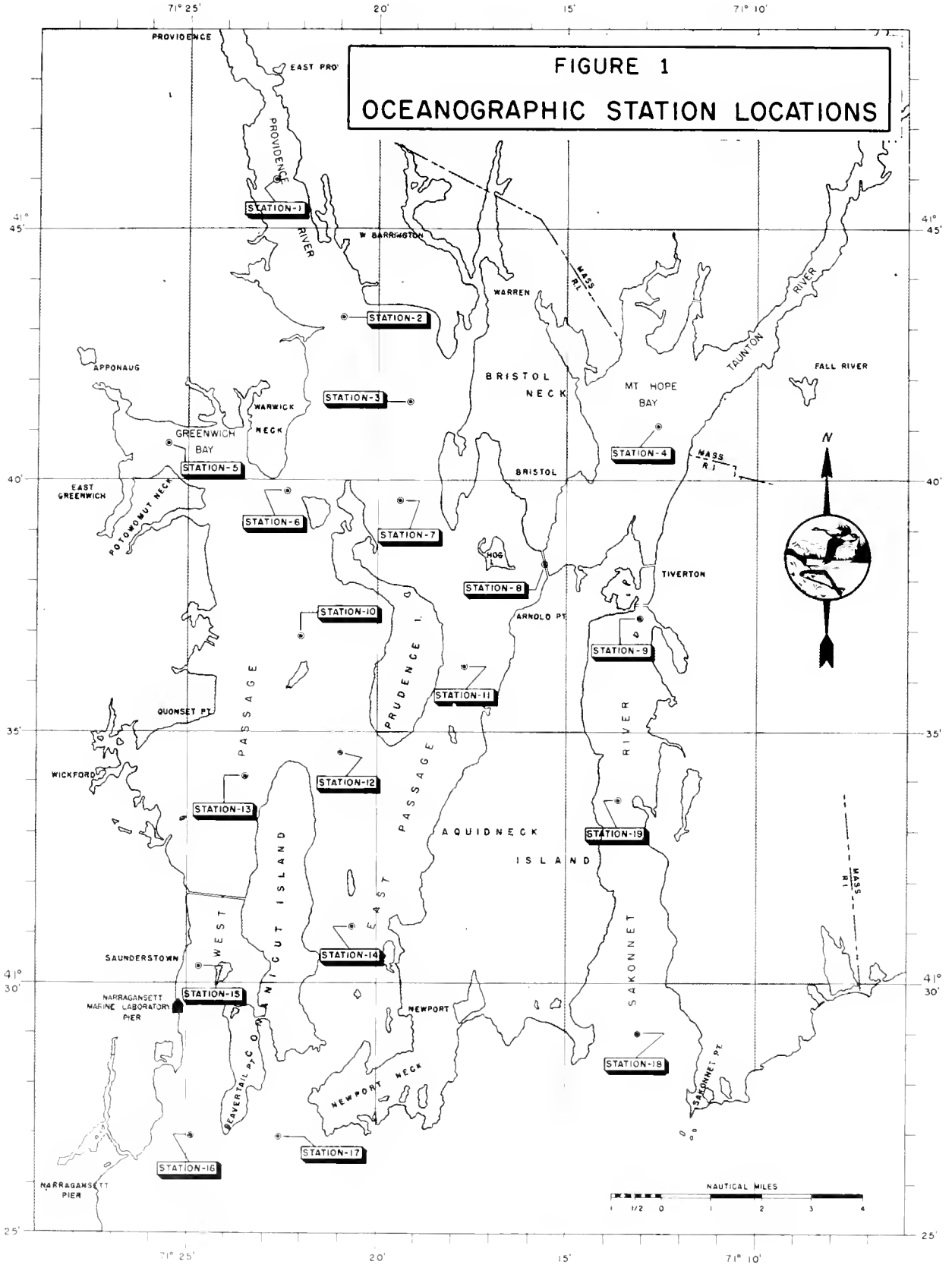
FIGURE 1
OCEANOGRAPHIC STATION LOCATIONS
71° 25'
20'
15'
71° 10'
41° 45'
40'
35'
41° 30'
25'
PROVIDENCE
EAST PROV
PROVIDENCE RIVER
STATION-1
W BARRINGTON
WARREN
MASS R I
STATION-2
TAUNTON RIVER
FALL RIVER
APPONAUG
BRISTOL NECK
MT HOPE BAY
STATION-3
WARWICK NECK
GREENWICH BAY
STATION-5
STATION-4
BRISTOL
EAST GREENWICH
POTOWOMUT NECK
STATION-6
STATION-7
HOG I
STATION-8
TIVERTON
ARNOLD PT
STATION-10
STATION-9
PRUDENCE I
QUONSET PT
STATION-11
PASSAGE
RIVER
WICKFORD
STATION-12
STATION-13
EAST PASSAGE
AQUIDNECK ISLAND
STATION-19
WEST
CONNICUT ISLAND
SAUNDERSTOWN
STATION-14
SAKONNET
NARRAGANSETT MARINE LABORATORY PIER
STATION-15
NEWPORT
BEAVERTAIL PT
STATION-18
NEWPORT NECK
SAKONNET PT
STATION-17
STATION-16
NARRAGANSETT PIER
N
NAUTICAL MILES
1 1/2 0 1 2 3 4

PHYSICAL OCEANOGRAPHIC STUDIES OF NARRAGANSETT BAY 1957 and 1958

by

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ABSTRACT

Narrangansett Bay seasonal distribution patterns of temperature, salinity, dissolved oxygen, and total phosphorus for 1957 are presented in sectional diagrams and summarized in tables. In addition, weekly observations of these parameters are graphed for a pier station near the Bay entrance.

INTRODUCTION

This paper presents the physical oceanographic data obtained on four quarterly cruises of the U.S. Fish and Wildlife Service vessel *Phalarope II* in greater Narragansett Bay, Rhode Island. These cruises were made as part of an overall study of the Bay and its resources for the prupose of evaluating the potential effects of proposed hurricane barriers. The area covers Narragansett Bay proper, Mt. Hope Bay, Greenwich Bay, and the Providence and Sakonnet Rivers.

COLLECTION OF DATA

The cruises, together with their inclusive dates and number of stations, were as follows: cruise 1, January 22-February 8, 1957 (18 stations); cruise 2, April 15-22, 1957 (19 stations); cruise 3, July 15-19, 1957 (19 stations); cruise 4, November 11-16, 1957 (19 stations). The station locations are shown in figure 1. The data collected are listed in appendix tables 1-4. Station 19, in the Sakonnet River, was not occupied on cruise 1.

All stations were occupied at "slack before ebb" ± 1 hour. Water samples were obtained with a Nansen bottle at four depths, approximately equal in spacing, from the surface to the bottom. On cruise 1, temperature measurements were made with a protected reversing thermometer attached to the Nansen bottle. A thermistor thermometer was used at every 1- or 2-meter interval (depending on depth) on cruises 2, 3, and 4.

Materials and Methods

All water samples were analyzed for their dissolved oxygen content after each days collecting by the standard Winkler method. Total phosphorus and chlorinity determinations were made on each water sample by the Woods Hole Oceanographic Institution; the former, by the modified Harvey method (Ketchum, Corwin, and Keen, 1955) and the latter, by the standard Mohr-Knudsen titration.

Note.--Steacy D. Hicks now with the Coast and Geodetic Survey, U.S. Department of Commerce, Washington, D.C.

The cruise data are presented according to the method suggested by Montgomery (1954). Three diagrams are used for each cruise (figs. 2-13). The diagrams illustrate the fields of temperature, dissolved oxygen and total phosphorus superimposed upon salinity. Salinity was chosen as the base field because of its relative stability, in comparison with other variables, in tidal estuaries. Each diagram contains three longitudinal sections along the axes of the major passage systems. These are Mt. Hope Bay and the Sakonnet River, the Providence River and East Passage, and Greenwich Bay and West Passage. The vertical arrows show the interconnections between passages. They point in the direction of the net nontidal drift.

The field of salinity was drawn first for each cruise. The fields of temperature, dissolved oxygen, and total phosphorus were then drawn upon the salinity field. All observed value points were included in the construction of the contours. The contours however were drawn to conform, whenever possible, to the pattern of the underlying salinity distribution.

Summarizing generalizations of each variable are presented in tables 1-4.

Stations were also made at the end of the Narragansett Marine Laboratory pier during the period, February 1957-February 1958. Temperature measurements (using a reversing thermometer and frame) and water samples were obtained from the surface and bottom at weekly intervals. The water samples were collected with a Kemmerer bottle and analyzed for their dissolved oxygen, chlorinity, and total phosphorus contents as described above. The results of this series are graphed in figure 14.

Study was financially supported by the U.S. Fish and Wildlife Service and the U.S. Army Corps of Engineers. Oscar W. Moreau of the Branch of River Basin Studies, Fish and Wildlife Service prepared the finished sectional diagrams. I wish to express my appreciation to Russell T. Norris and the members of the Fishery Advisory Committee (Narragansett Bay Hurricane Barrier Research Program) for their encouragement and advice.

Table 1.--Seasonal salinity trends and ranges

	Winter	Spring	Summer	Autumn
General surface tendency from heads to entrances	Increase	Increase	Increase	Increase
General surface range (^{o}/oo)	24.5-32.0	20.5-31.5	29.5-32.5	29.0-32.5
General bottom tendency from heads to entrances	Increase	Increase	Increase	Increase
General bottom range (^{o}/oo)	29.0-32.5	27.0-32.0	31.0-32.0	30.5-32.5
Uniform horizontal gradient	No	Yes	Yes	Yes
General tendency from surface to bottom	Increase	Increase	Increase	Increase
Vertical stratification	Moderate	Intense	Light	Light to none
Station no. 11 (77 ft.)	2.2 ^{o}/oo	6.3 ^{o}/oo	1.0 ^{o}/oo	0.1 ^{o}/oo

Table 2.--Seasonal temperature trends and ranges

	Winter	Spring	Summer	Autumn
General surface tendency from heads to entrances	Increase 1/	Decrease	Decrease	Increase
General surface range (^{o}C)	0.0-2.0	11.5-5.5	23.0-18.5	9.0-12.0
General bottom tendency from heads to entrances	Increase 2/	Decrease	Decrease	Increase
General bottom range (^{o}C)	0.0-2.5	8.0-5.0	22.0-15.5	9.0-13.0
Uniform horizontal gradients	No	No	No	Yes
General tendency from surface to bottom	Increase 2, 3/	Decrease	Decrease	Increase
Vertical stratification	None	Intense to light	Moderate	None
Station no. 11 (77 ft.)	0.3^{o} C	-0.9^{o} C	-4.2^{o} C	1.0^{o} C

1/ In West and East Passages only

2/ Except in Mt. Hope Bay and Sakonnet River

3/ Decreases in Providence River

Table 3.--Seasonal oxygen trends and ranges

	Winter	Spring	Summer	Autumn
General surface tendency from heads to entrances	None	None	Increase 1/	None
General surface range (ml./1.)	6.5-8.5	6.0-9.0	3.5-5.5	2.5-3.5
General bottom tendency from heads to entrances	None	None	Increase 1/	None
General bottom range (ml./1.)	6.5-8.0	6.0-6.5	3.0-4.5	3.0-3.5
Uniform horizontal gradients	No	No	No	No
General tendency from surface to bottom	None	None 2/	Decrease 3/	None
Vertical stratification	None	None	Light	None
Station no. 11 (77 ft.)	-0.1 ml./1.	-1.0 ml./1.	-1.3 ml./1	0

1/ Except in Mt. Hope Bay and Providence River

2/ Except in Providence River and upper East Passage where it decreases

3/ Except in the Providence River near the bottom where it increases

Table 4.--Seasonal phosphorus trends and ranges

	Winter	Spring	Summer	Autumn
General surface tendendy from heads to entrances	Decrease	Decrease[1/]	Decrease	Decrease[2/]
General surface range (μg.-at./1.)	5.5-1.2	3.5-0.8	14.0-1.8	6.5-1.4
General bottom tendency from heads to entrances	Decrease	Decrease[2,3/]	Decrease	Decrease[2/]
General bottom range (μg.-at./1.)	3.0-1.4	2.2-1.0	4.4-1.4	6.5-1.6
Uniform horizontal gradients	No[3/]	No	Yes	Yes
General tendency from surface to bottom	Decrease[1/]	Decrease[4/]	Decraase	Increase[5/]
Vertical stratification	Moderate to light	None	Moderate	None[6/]
Station no. 11 (77 ft.)	-0.4μg.-at./1.	-0.3μg.-at./1.	-1.5μg.-at./1.	0.8μg.-at./1.

1/ Except at the mouths of East Passage and the Sakonnet River

2/ Except in Greenwich Bay

3/ Except in West Passage

4/ Except in West Passage and the Sakonnet River

5/ A phosphorus minimum layer occurs at mid-depth

6/ Minimum layer about 0.1 μ g.-at/l. less than above and below

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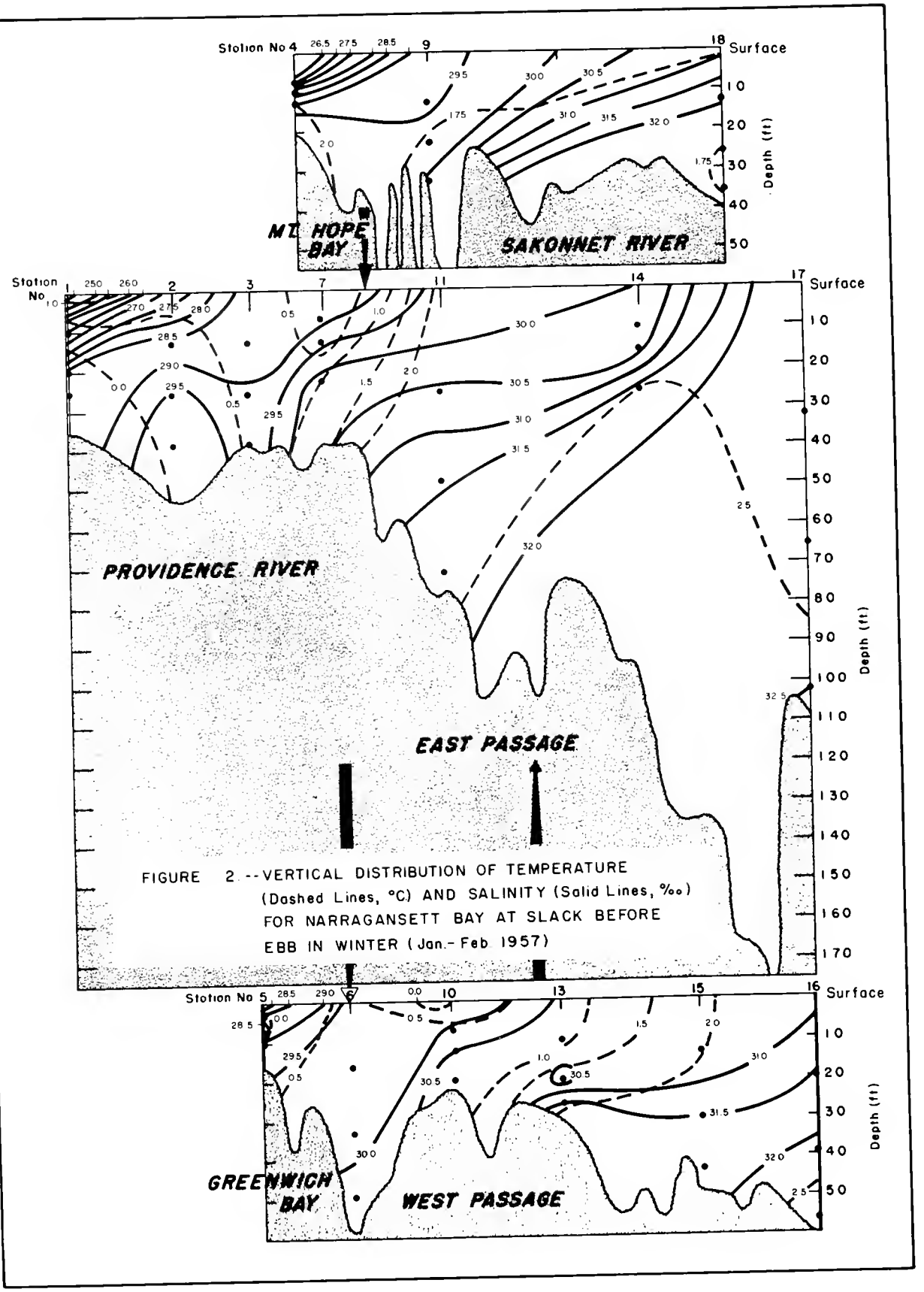

FIGURE 2 --VERTICAL DISTRIBUTION OF TEMPERATURE (Dashed Lines, °C) AND SALINITY (Solid Lines, ‰) FOR NARRAGANSETT BAY AT SLACK BEFORE EBB IN WINTER (Jan.- Feb 1957)

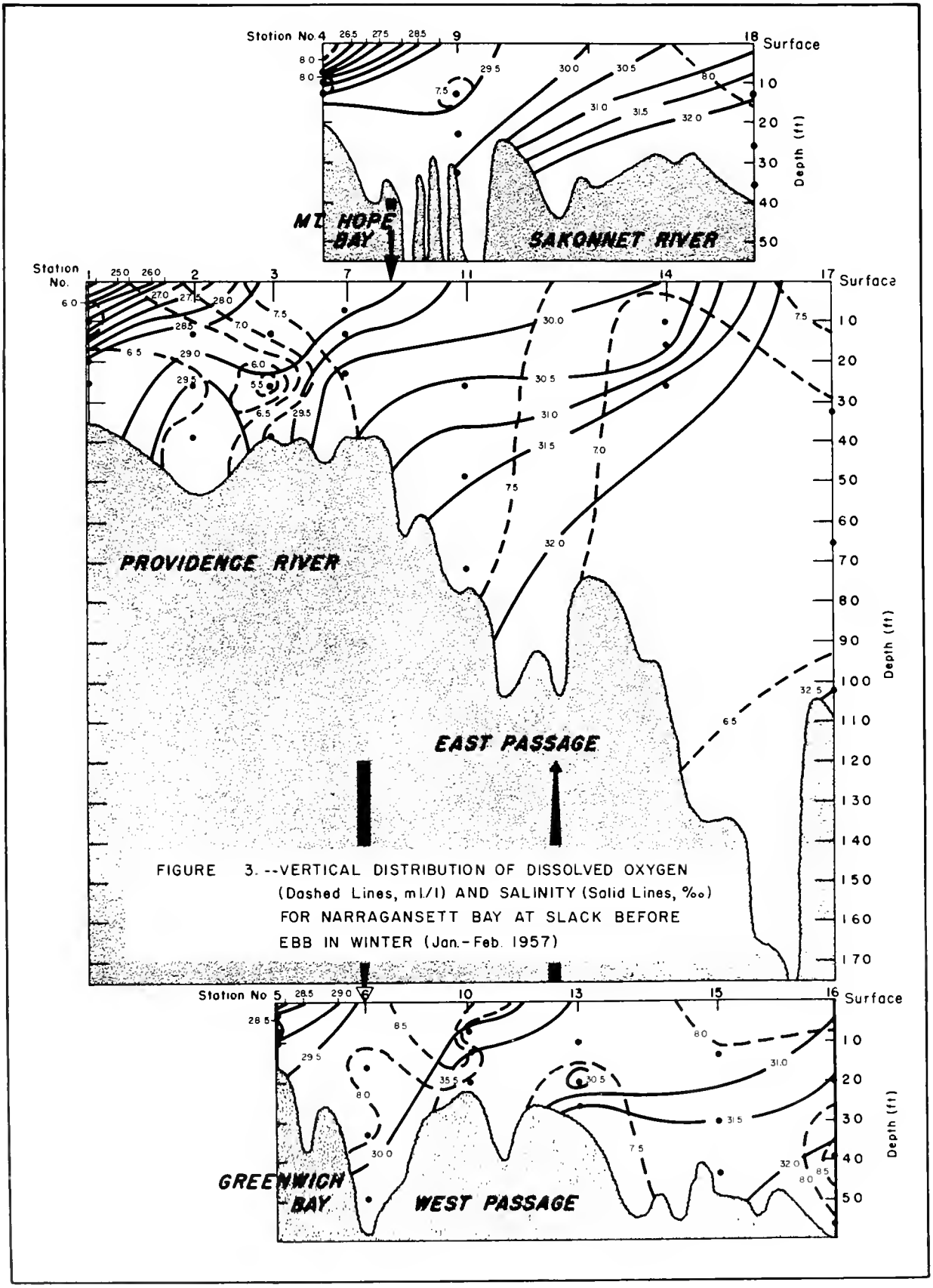

FIGURE 3.--VERTICAL DISTRIBUTION OF DISSOLVED OXYGEN (Dashed Lines, ml/l) AND SALINITY (Solid Lines, ‰) FOR NARRAGANSETT BAY AT SLACK BEFORE EBB IN WINTER (Jan.-Feb. 1957)

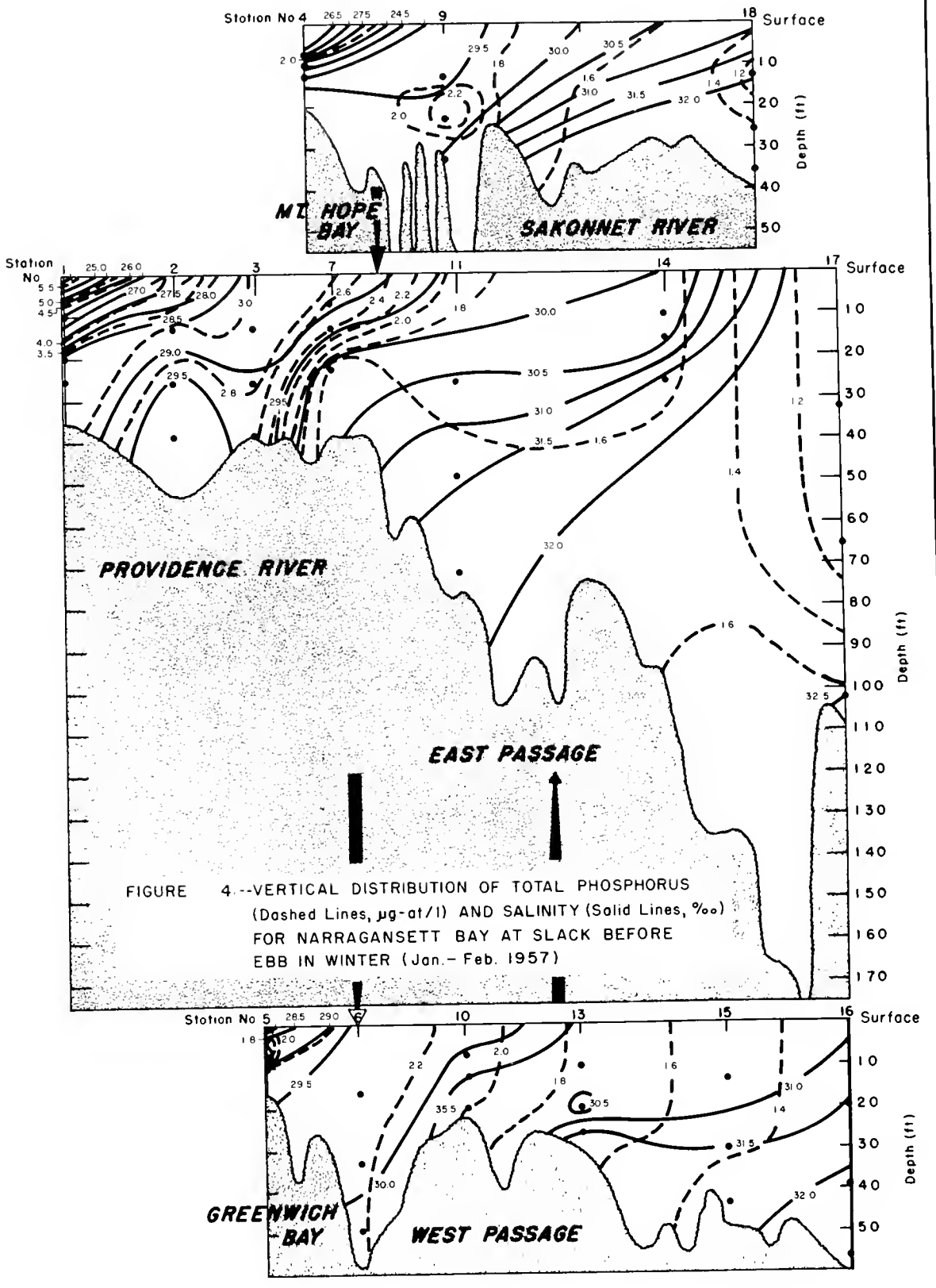

FIGURE 4.--VERTICAL DISTRIBUTION OF TOTAL PHOSPHORUS (Dashed Lines, µg-at/l) AND SALINITY (Solid Lines, ‰) FOR NARRAGANSETT BAY AT SLACK BEFORE EBB IN WINTER (Jan.- Feb. 1957)

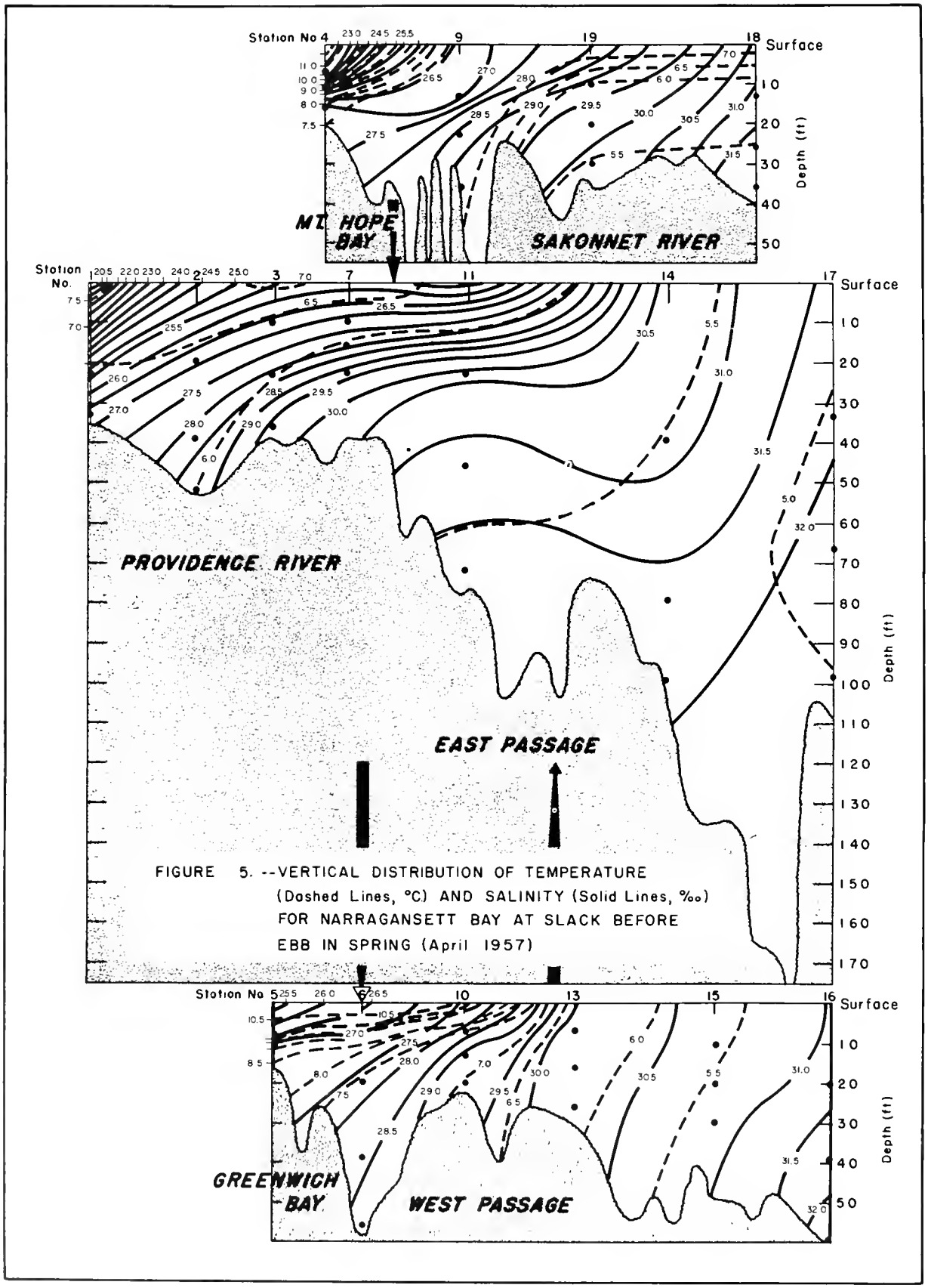

FIGURE 5. --VERTICAL DISTRIBUTION OF TEMPERATURE (Dashed Lines, °C) AND SALINITY (Solid Lines, ‰) FOR NARRAGANSETT BAY AT SLACK BEFORE EBB IN SPRING (April 1957)

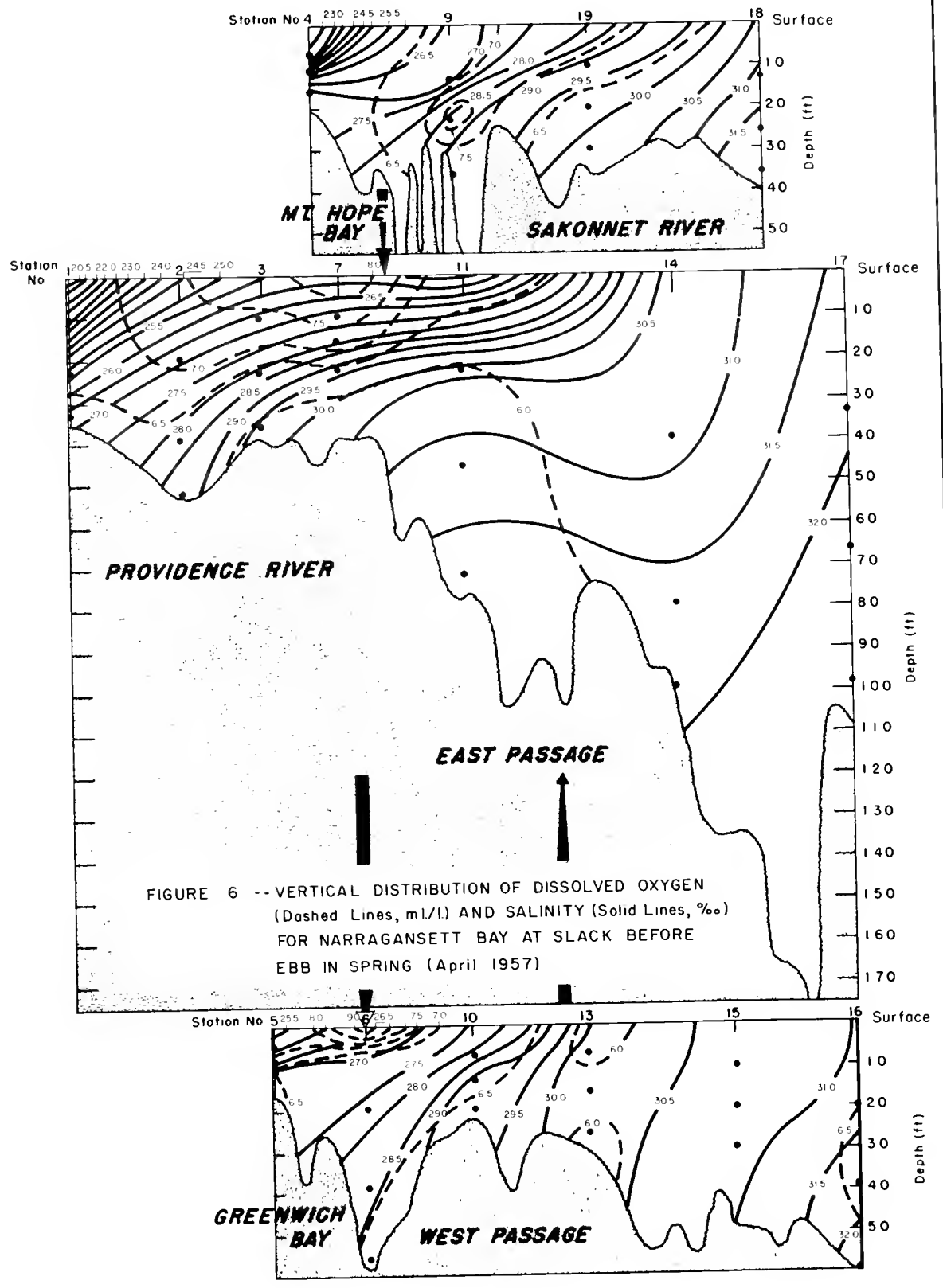

FIGURE 6 -- VERTICAL DISTRIBUTION OF DISSOLVED OXYGEN (Dashed Lines, ml./l.) AND SALINITY (Solid Lines, ‰) FOR NARRAGANSETT BAY AT SLACK BEFORE EBB IN SPRING (April 1957)

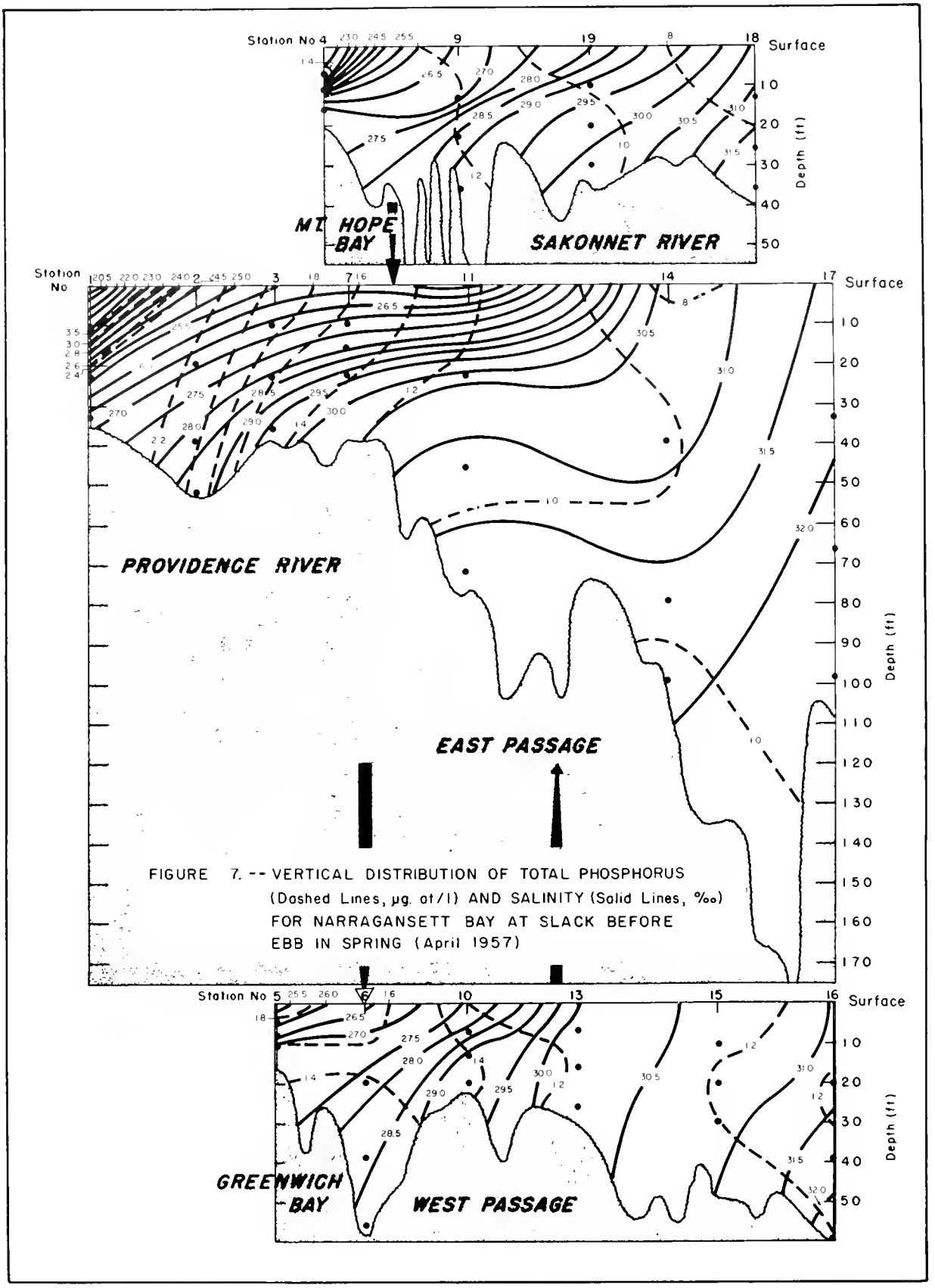

FIGURE 7. -- VERTICAL DISTRIBUTION OF TOTAL PHOSPHORUS (Dashed Lines, µg. at/l) AND SALINITY (Solid Lines, ‰) FOR NARRAGANSETT BAY AT SLACK BEFORE EBB IN SPRING (April 1957)

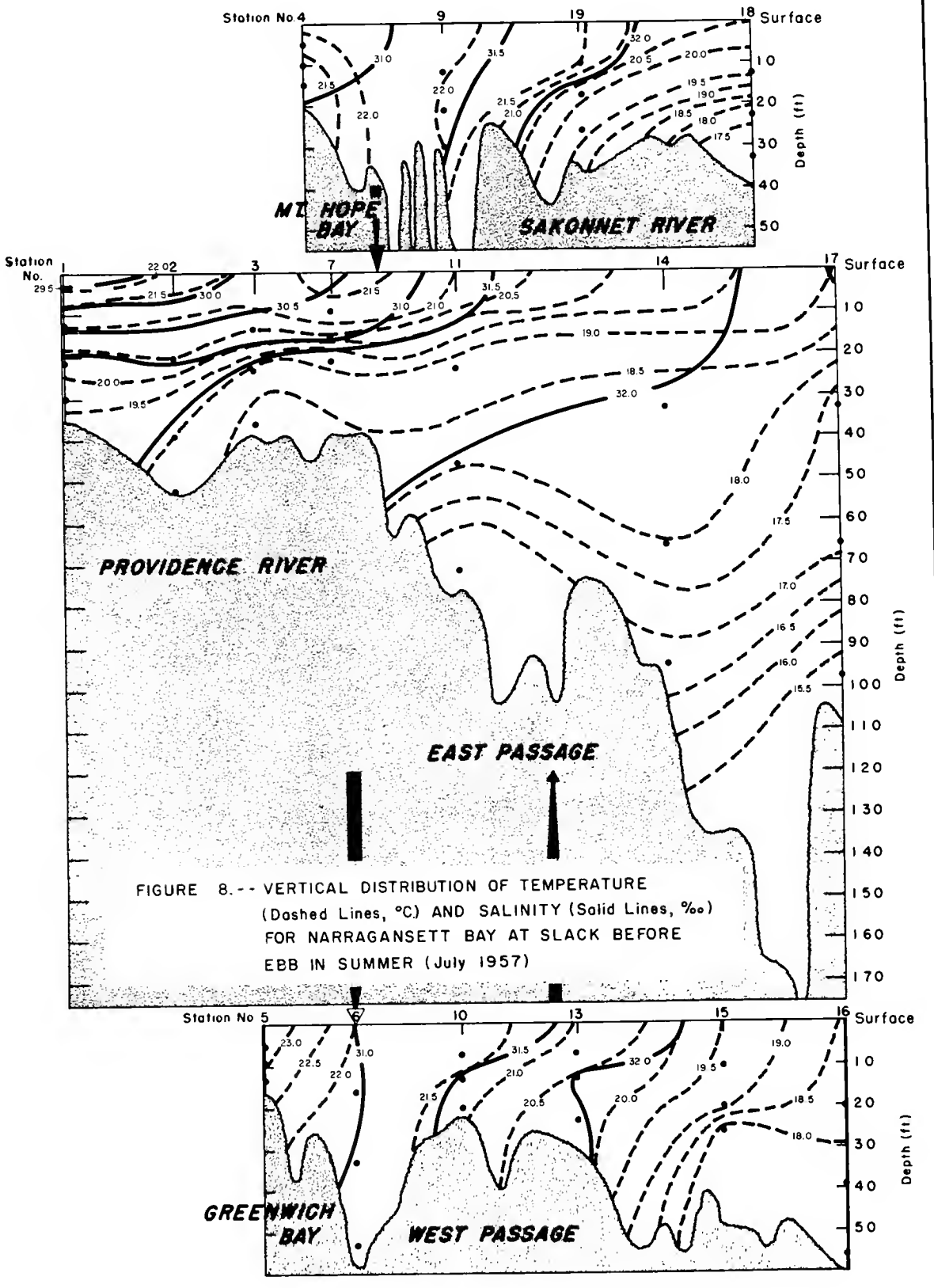

FIGURE 8.-- VERTICAL DISTRIBUTION OF TEMPERATURE (Dashed Lines, °C) AND SALINITY (Solid Lines, ‰) FOR NARRAGANSETT BAY AT SLACK BEFORE EBB IN SUMMER (July 1957)

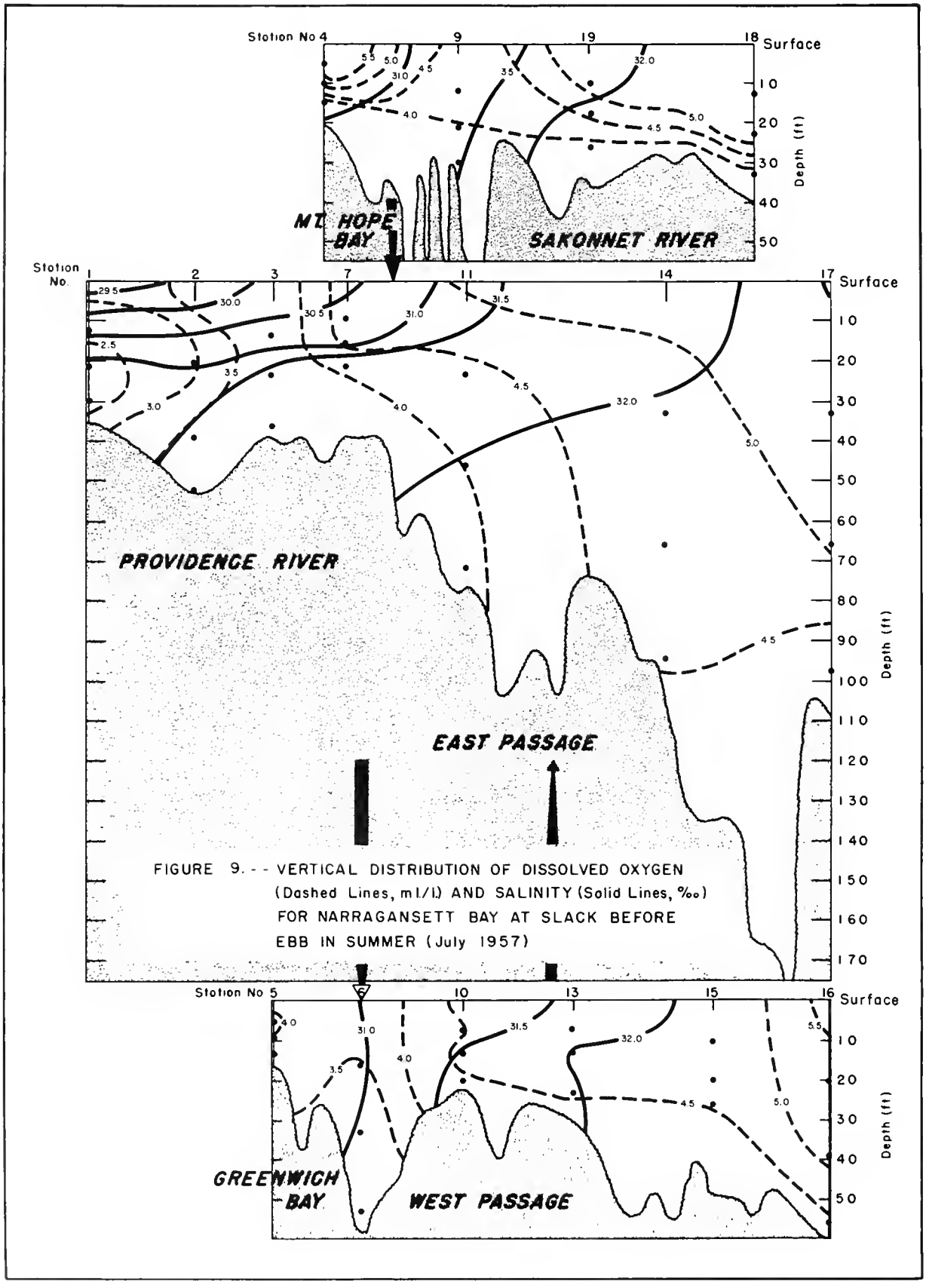

FIGURE 9. - - VERTICAL DISTRIBUTION OF DISSOLVED OXYGEN (Dashed Lines, ml/l) AND SALINITY (Solid Lines, ‰) FOR NARRAGANSETT BAY AT SLACK BEFORE EBB IN SUMMER (July 1957)

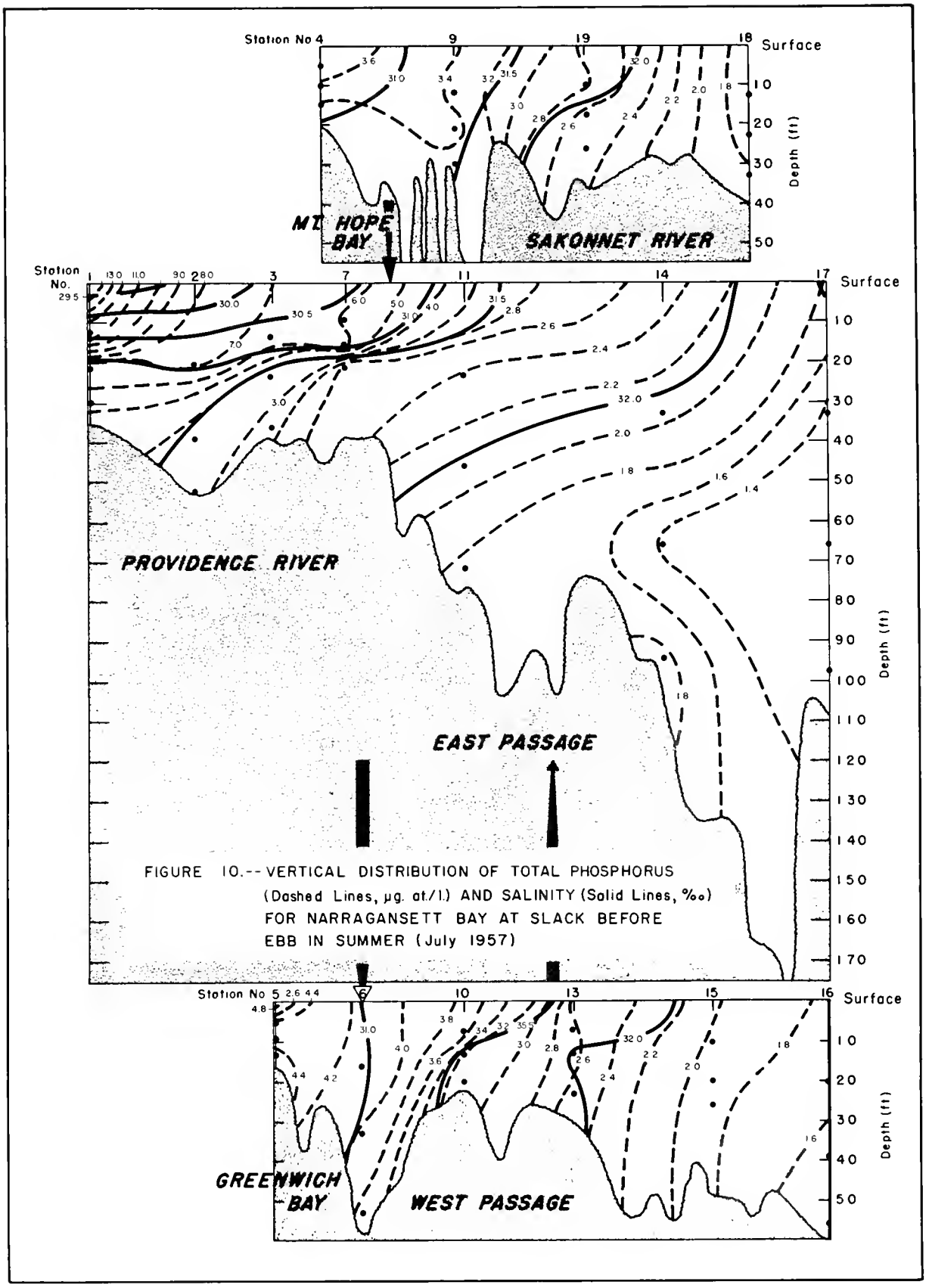

FIGURE 10.--VERTICAL DISTRIBUTION OF TOTAL PHOSPHORUS (Dashed Lines, µg. at./l.) AND SALINITY (Solid Lines, ‰) FOR NARRAGANSETT BAY AT SLACK BEFORE EBB IN SUMMER (July 1957)

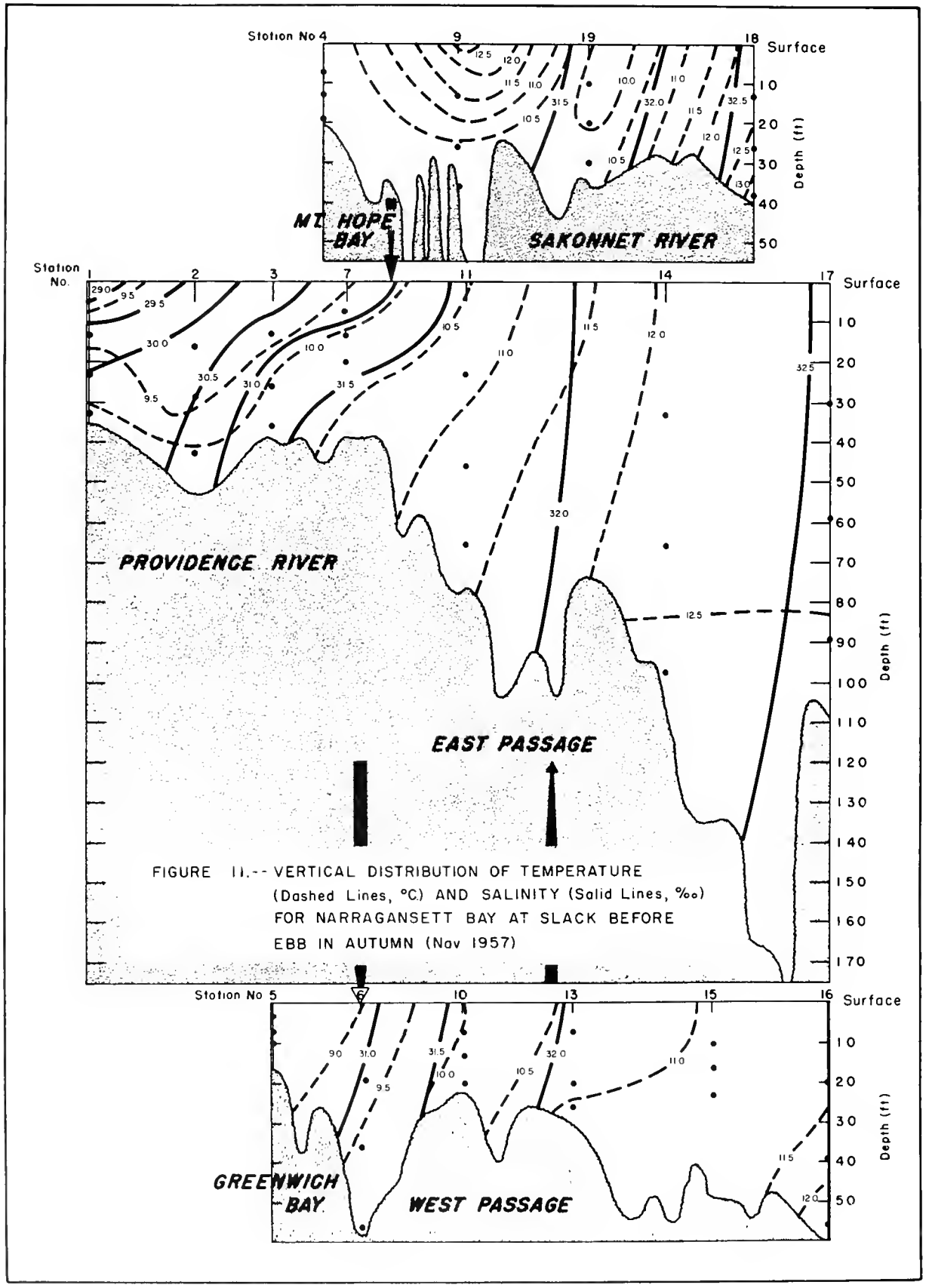

FIGURE 11.-- VERTICAL DISTRIBUTION OF TEMPERATURE (Dashed Lines, °C) AND SALINITY (Salid Lines, ‰) FOR NARRAGANSETT BAY AT SLACK BEFORE EBB IN AUTUMN (Nov 1957)

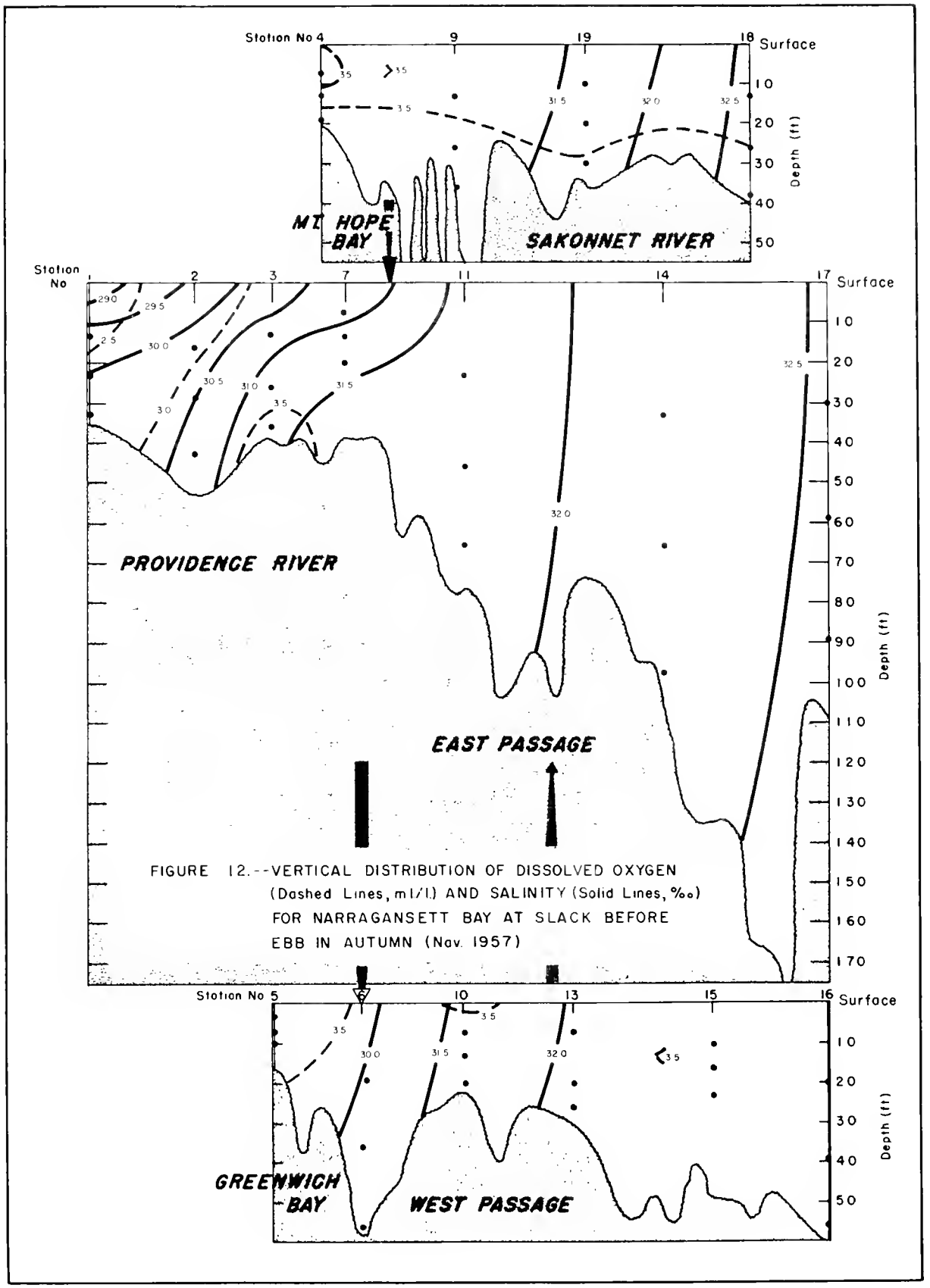

FIGURE 12.--VERTICAL DISTRIBUTION OF DISSOLVED OXYGEN (Dashed Lines, ml/l.) AND SALINITY (Solid Lines, ‰) FOR NARRAGANSETT BAY AT SLACK BEFORE EBB IN AUTUMN (Nov. 1957)

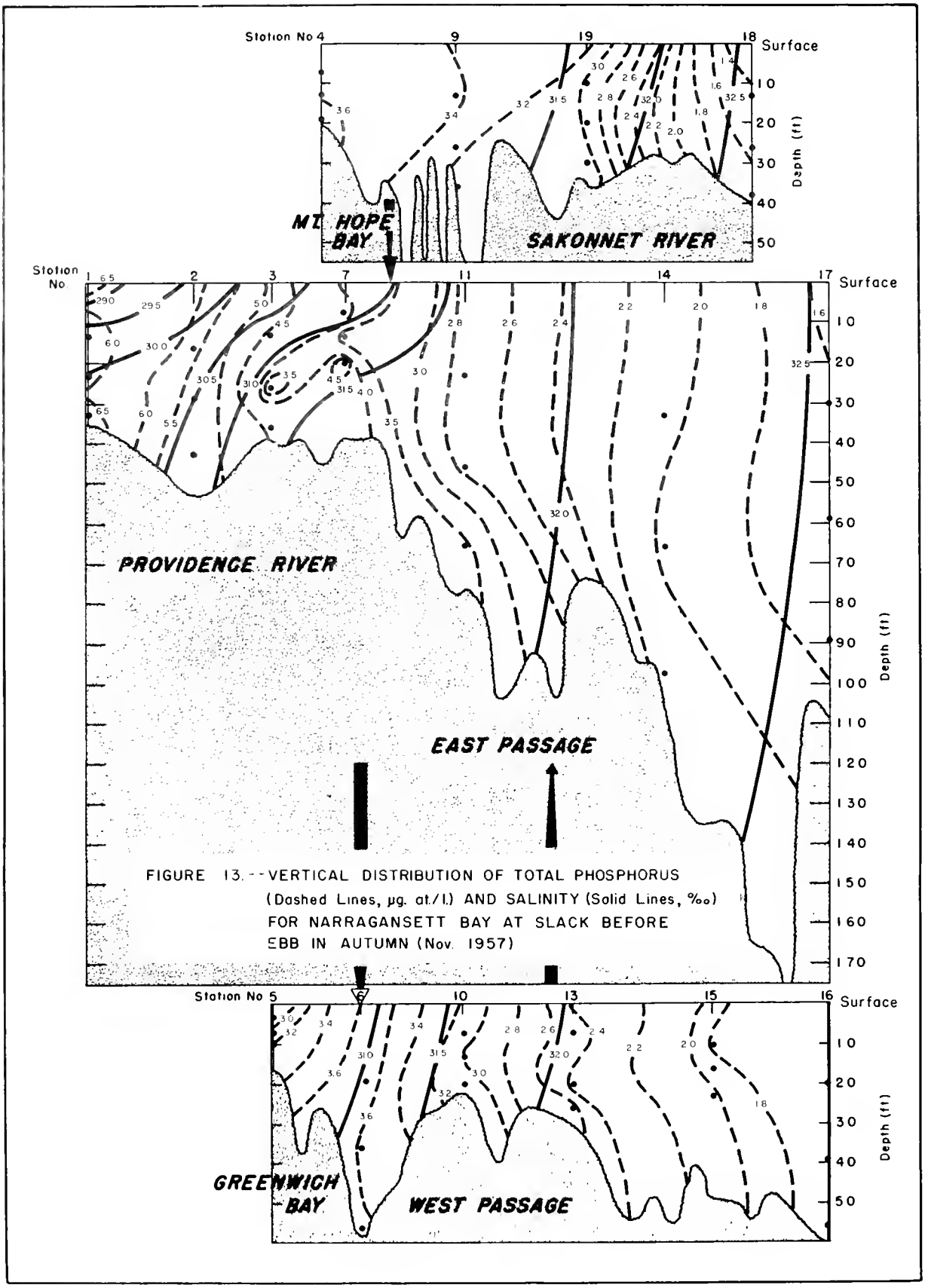

FIGURE 13.--VERTICAL DISTRIBUTION OF TOTAL PHOSPHORUS (Dashed Lines, µg. at./l.) AND SALINITY (Solid Lines, ‰) FOR NARRAGANSETT BAY AT SLACK BEFORE EBB IN AUTUMN (Nov. 1957)

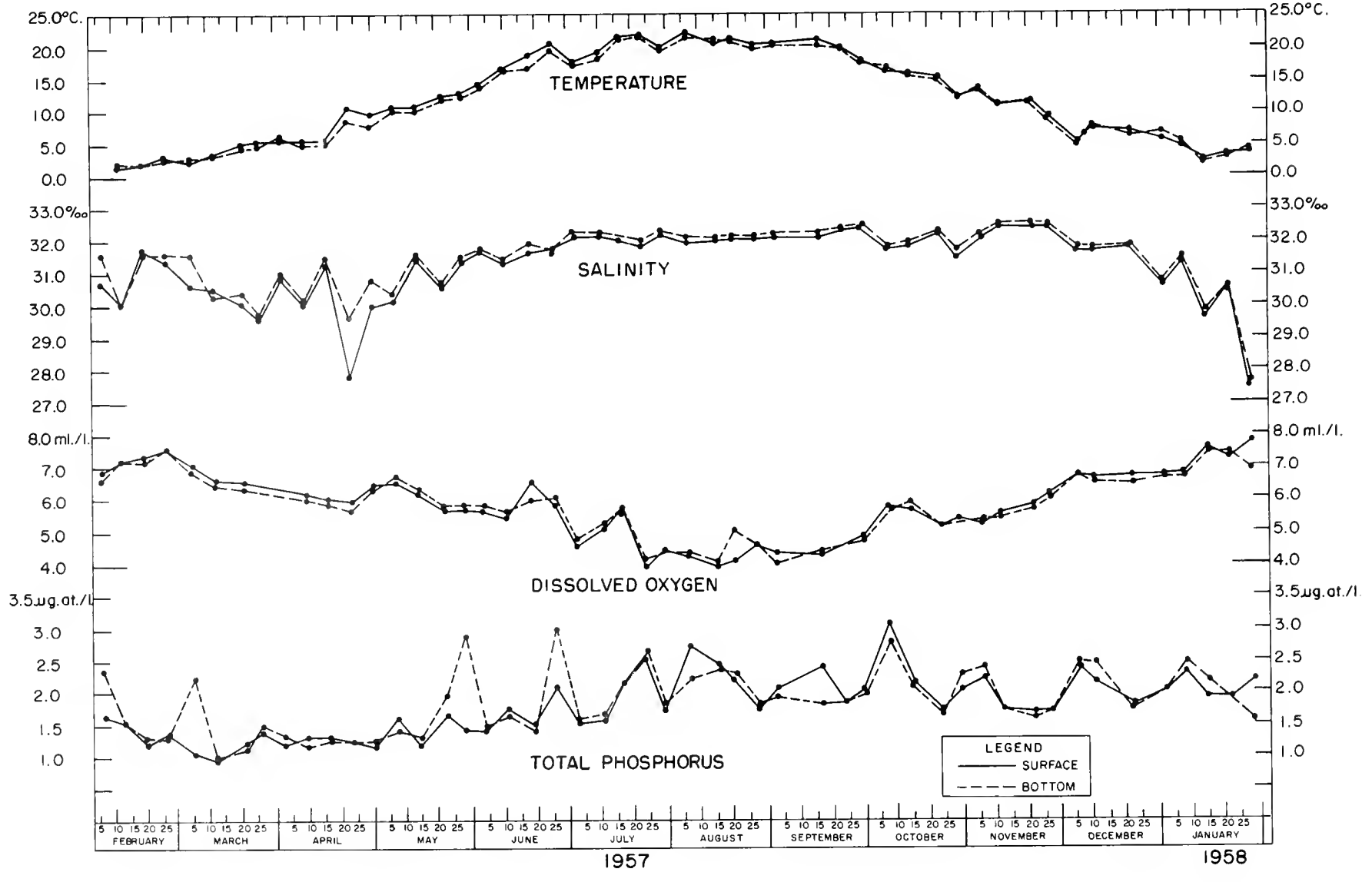

FIGURE 14. -- YEARLY CYCLE OF TEMPERATURE, SALINITY, DISSOLVED OXYGEN AND TOTAL PHOSPHORUS AT THE NARRAGANSETT MARINE LABORATORY PIER, RHODE ISLAND.

Appendix table 1.--Cruise 1, January 22 to February 8, 1957

Station	Date	Time (Est.)	Depth	Temperature	Salinity	Oxygen	Total PO_4-P
			Feet	*°C*	*‰*	*Ml./l.*	*Mg.-at./l.*
1	Jan. 22	1217	0	1.41	24.20	6.02	5.86
			10	0.32	26.76	5.96	4.61
			20	-0.28	28.60	6.94	3.13
			26	-0.19	28.59	6.88	3.34
2	Jan. 22	1329	0	0.69	27.21	7.26	3.91
			13	0.10	28.69	6.04	2.84
			26	0.04	29.53	6.74	2.62
			39	0.07	29.73	6.08	2.62
3	Jan. 23	1251	0	0.88	28.78	7.92	2.99
			13	0.83	28.82	7.19	2.90
			26	0.80	29.05	5.40	2.92
			39	0.83	29.38	7.34	2.62
4	Feb. 4	0938	0	1.80	26.42	8.35	2.10
			7	1.78	26.51	7.74	2.10
			10	1.92	28.49	8.13	1.97
			13	2.10	29.22	7.53	1.98
5	Jan. 24	1351	0	0.01	27.92	8.42	2.10
			3	-0.08	28.87	8.28	1.78
			7	-0.10	28.32	8.02	1.97
			10	0.04	29.17	8.12	2.32
6	Jan. 23	1404	0	0.68	29.79	4.00	2.29
			16	0.59	29.91	7.94	2.24
			33	0.62	29.91	8.07	2.27
			49	0.59	30.15	7.61	2.21
7	Jan. 24	1519	0	0.45	28.37	7.80	2.86
			7	0.45	28.69	7.80	2.59
			13	0.36	29.49	3.55	2.40
			23	1.02	30.31	7.84	1.54
8	Feb. 4	1052	0	2.10	29.87	7.68	1.86
			23	2.25	29.93	7.40	1.72
			45	2.48	30.80	7.37	1.62
			72	2.52	31.03	7.55	1.59
9	Feb. 6	1100	0	1.78	29.41	7.86	1.88
			13	1.79	29.45	7.35	1.83
			23	1.74	29.77	7.77	2.30
			33	1.71	30.02	7.76	1.94
10	Jan. 25	1450	0	0.00	29.52	8.62	2.13
			7	0.51	30.16	7.80	2.05
			13	0.68	30.52	8.68	2.10
			20	0.82	30.76	7.62	2.00
11	Feb. 5	1150	0	2.12	29.59	7.66	1.81
			26	2.24	30.55	7.81	1.73
			49	2.42	31.46	7.63	1.57
			72	2.47	31.84	7.78	1.55
12	Feb. 5	1020	0	2.29	30.73	7.88	1.65
			36	2.28	31.45	7.73	1.62

Appendix table 1.--Cruise 1, January 22 to February 8, 1957--Con.

Station	Date	Time (Est.)	Depth	Temperature	Salinity	Oxygen	Total PO_4-P
			Feet	*°C*	*‰*	*Ml./l.*	*Mg.-at./l.*
			76	2.47	32.28	7.58	1.49
			112	2.95	32.27	7.85	1.58
13	Jan. 25	1540	0	0.82	30.64	7.82	1.78
			10	0.90	30.69	7.78	1.78
			20	1.81	31.40	7.42	1.65
			26	1.98	31.51	7.28	1.78
14	Feb. 8	1440	0	2.24	30.03	7.05	1.70
			10	2.24	30.10	6.88	1.70
			16	2.28	30.25	6.80	1.70
			26	2.50	31.73	6.54	3.12
15	Feb. 7	1315	0	1.98	30.53	8.11	1.44
			13	1.98	30.66	7.98	1.47
			30	2.35	31.50	7.68	1.44
			43	2.40	31.74	7.63	1.28
16	Feb. 7	1210	0	2.10	30.95	8.10	1.34
			20	2.31	31.61	7.79	1.41
			39	2.26	32.14	8.83	1.23
			56	2.62	32.44	7.52	1.34
17	Feb. 8	1302	0	2.26	32.07	7.55	1.10
			33	2.07	32.16	6.88	1.05
			66	2.10	32.36	6.67	1.05
			102	2.84	32.57	6.36	1.70
18	Feb. 6	1232	0	1.80	30.73	8.15	1.41
			13	1.62	31.90	8.06	1.15
			26	1.75	32.19	7.90	1.41
			36	1.75	32.20	7.84	1.36

Appendix table 2.--Cruise II, April 15 to April 22, 1957

Station	Date	Time (Est.)	Depth	Temperature	Salinity	Oxygen	Total PO_4-P
			Feet	°*C*	‰	*Ml./l.*	*Mg.-at./l.*
1	Apr. 16	0805	0	7.85	20.20	6.70	1.39
			10	7.01	22.30	6.71	3.88
			23	6.48	32.10	6.58	2.33
			33	6.38	26.99	6.42	2.38
2	Apr. 16	0843	0	6.72	24.19	7.47	2.40
			20	6.48	26.80	7.04	2.18
			39	6.05	28.12	6.37	2.04
			59	6.00	28.62	6.15	1.96
3	Apr. 16	0915	0	7.20	25.45	7.83	1.88
			10	6.49	26.63	7.43	2.20
			23	6.02	28.36	6.49	1.60
			36	5.60	29.61	5.93	1.47
4	Apr. 22	1427	0	11.80	22.05	6.14	1.28
			7	10.65	22.40	6.36	1.44
			12	9.25	25.88	6.14	1.28
			16	7.52	27.10	6.06	1.36
5	Apr. 19	1213	0	10.97	25.39	7.84	1.91
			5	10.26	25.99	7.60	1.67
			8	10.01	26.22	7.28	1.70
			11	9.04	27.02	6.28	1.52
6	Apr. 19	1130	0	13.10	21.97	9.38	3.02
			20	7.38	27.85	6.70	1.39
			39	7.33	28.31	6.77	1.28
			56	7.14	28.63	6.22	1.39
7	Apr. 16	0945	0	6.89	25.66	8.17	1.62
			10	6.18	27.23	7.73	1.52
			16	5.90	27.88	7.22	1.44
			23	5.59	29.42	6.49	1.47
8	Apr. 22	1330	0	11.95	23.09	6.40	1.15
			20	7.63	28.12	6.14	1.13
			39	5.88	30.75	5.82	1.13
			59	5.52	31.27		.94
9	Apr. 18	1130	0	7.40	26.91	6.85	1.15
			13	7.39	26.93	6.79	1.33
			23	7.41	28.78	7.69	1.07
			36	7.39	26.95	6.70	1.34
10	Apr. 19	1028	0	10.03	27.57	6.72	1.20
			7	7.31	28.22	6.63	1.31
			13	7.31	29.14	6.63	1.41
			20	6.64	29.14	6.32	1.52
11	Apr. 22	1242	0	11.38	25.41	6.74	1.26
			23	6.94	30.48	5.98	1.15
			46	5.78	31.26	5.82	1.05
			72	5.38	31.72	5.88	.92
12	Apr. 17	0929	0	6.08	29.72	6.29	1.07
			10	6.04	29.56	6.41	1.07

Appendix table 2.--Cruise II, April 15 to April 22, 1957--Con.

Station	Date	Time (Est.)	Depth	Temperature	Salinity	Oxygen	Total PO_4-P
			Feet	°*C*	‰	*Ml./l.*	*Mg.-at./l.*
			20	5.48	30.41	6.14	1.23
			30	5.37	30.76	6.02	1.36
13	Apr. 17	0957	0	6.29	30.08	5.99	1.10
			7	6.29	30.11	5.96	1.13
			16	6.29	30.08	6.01	1.18
			26	6.28	30.15	5.94	1.05
14	Apr. 17	0847	0	5.68	30.60	6.21	0.79
			39	5.49	30.83	6.13	1.07
			79	5.26	31.61	6.13	0.97
			112	5.22	31.72	6.09	1.10
15	Apr. 15	0855	0	5.57	30.80	6.43	1.07
			10	5.54	30.86	6.34	1.15
			20	5.47	30.81	6.35	1.33
			30	5.29	30.91	6.36	1.18
16	Apr. 15	0809	0	5.10	31.09	6.31	1.31
			20	5.17	31.29	6.49	1.02
			39	5.19	31.81	6.64	1.23
			59	5.08	32.24	6.13	1.20
17	Apr. 15	0731	0	5.05	31.77	6.42	0.92
			33	4.99	31.93	6.33	0.97
			66	4.95	32.28	6.06	0.94
			98	5.00	32.39	6.15	0.94
18	Apr. 18	1000	0	7.05	30.72	6.46	0.65
			13	5.87	31.44	6.39	0.76
			26	5.48	31.86	6.33	0.86
			36	5.41	31.88	6.30	0.94
19	Apr. 18	1041	0	7.05	27.87	7.26	0.84
			10	5.95	29.26	6.55	0.97
			20	5.82	29.88	6.34	1.10
			30	5.42	30.05	6.26	1.18

Appendix table 3.--Cruise III, July 15 to July 19, 1957

Station	Date	Time (Est.)	Depth	Temperature	Salinity	Oxygen	Total PO_4-P
			Feet	*°C*	*‰*	*Ml./l.*	*Mg.-at./l.*
1	July 17	1100	0	22.20	29.16	3.17	14.40
			12	21.03	30.26	2.58	11.70
			21	20.15	31.03	2.47	6.40
			30	19.58	31.32	2.45	5.01
2	July 17	1025	0	22.15	29.70	3.90	8.04
			20	20.72	30.70	2.96	7.12
			39	19.00	31.61	3.65	3.70
			56	18.90	31.66	3.63	3.14
3	July 17	0956	0	21.30	30.24	3.62	7.00
			13	20.80	30.71	3.65	6.40
			23	18.90	31.58	3.77	3.66
			36	18.23	31.86	3.83	2.96
4	July 18	1219	0	22.02	30.62	5.61	3.67
			5	21.95	30.65	5.68	3.77
			10	21.40	30.84	5.43	3.56
			15	21.19	30.96	3.91	3.35
5	July 15		0	23.07	30.87	4.33	4.82
			5	23.06	30.85	3.99	4.24
			9	23.00	30.83	4.16	4.35
			13	22.94	30.85	4.16	4.45
6	July 15	0932	0	22.00	31.00	3.58	4.17
			16	21.86	30.96	3.43	4.09
			33	21.84	31.01	3.36	3.98
			53	21.72	31.18	3.37	3.72
7	July 17	0927	0	21.70	30.44	4.46	6.10
			9	21.39	30.70	4.67	5.76
			15	20.60	30.94	4.88	6.35
			21	19.34	31.81	4.02	2.54
8	July 19	1105	0	21.74	31.16	4.93	2.88
			23	20.52	31.37	4.66	2.93
			46	19.08	31.68	4.31	2.70
			69	18.47	31.92	3.74	2.25
9	July 18	1132	0	22.28	31.32	4.39	3.43
			12	22.01	31.32	4.35	3.24
			21	21.97	31.32	3.96	3.50
			30	22.00	31.34	3.99	3.22
10	July 15	0855	0	21.79	31.26	4.85	3.74
			7	21.78	31.36	4.37	3.74
			13	21.16	31.58	4.87	3.20
			20	21.04	31.66	4.45	3.10
11	July 19	1145	0	21.00	31.45	5.07	3.06
			23	18.92	31.86	4.40	2.33
			46	18.07	32.11	4.03	2.04
			72		32.33	3.96	1.75
12	July 19	1225	0	21.20	31.74	5.49	2.57
			10	20.36	31.65	5.54	2.46

Appendix table 3.--Cruise III, July 15 to July 19, 1957--Con.

Station	Date	Time (Est.)	Depth	Temperature	Salinity	Oxygen	Total PO_4-P
			Feet	°*C*	‰	*Ml./l.*	*Mg.-at./l.*
			20	18.62	31.92	4.81	2.28
			26	18.00	32.04	4.17	2.20
13	July 15	0810	0	20.91	31.76	4.72	2.49
			7	20.93	31.80	4.81	2.64
			13	20.49	32.01	4.67	2.62
			23	20.29	31.95	4.57	2.46
14	July 16	0850	0	19.79	31.74	5.13	2.49
			33	18.17	32.14	4.85	2.07
			66	18.00	32.37	4.66	1.42
			95	16.91	32.37	4.67	1.83
15	July 16	1058	0	19.50	32.15	4.70	2.04
			10	19.54	32.15	4.87	1.93
			20	19.13	32.15	4.65	1.96
			26	17.92	32.21	4.57	1.81
16	July 16	1012	0	18.47	32.16	5.60	1.70
			20	18.16	32.24	5.16	1.65
			39	17.84	32.38	5.07	1.55
			56	17.37	32.39	4.42	1.52
17	July 16	0950	0	18.98	32.51	5.35	.76
			33	17.34	32.48	5.25	1.31
			66	17.22	32.48	5.05	1.21
			98	15.30	32.49	4.19	1.36
18	July 18	1005	0	20.52	32.19	5.30	1.60
			13	19.58	32.31	5.28	1.65
			23	17.72	32.39	5.01	1.65
			33	17.08	32.44	3.88	1.99
19	July 18	1055	0	21.60	31.92	5.13	2.67
			10	21.50	31.92	5.15	2.96
			18	20.03	32.05	4.73	2.54
			26	19.95	32.10	3.86	2.54

Appendix table 4.--Cruise IV, November 11 to November 16, 1957

Station	Date	Time (Est.)	Depth	Temperature	Salinity	Oxygen	Total PO_4-P
			Feet	°*C*	‰	*Ml./l.*	*Mg.-at./l.*
1	Nov. 13	1102	0	10.00	28.53	2.12	6.92
			13	9.15	29.81	2.42	5.72
			23	9.79	30.01	2.54	5.50
			33	10.30	30.37	2.80	6.74
2	Nov. 13	1132	0	9.19	29.62	2.95	6.09
			16	9.13	30.19	2.98	5.57
			30	9.39	30.50	3.02	5.30
			43	10.10	30.85	3.07	5.18
3	Nov. 13	1155	0	9.05	30.42	3.30	4.56
			13	9.16	30.71	3.34	4.36
			26	10.23	31.34	3.17	3.43
			36	10.52	31.48	3.58	4.40
4	Nov. 15	1440	0	10.32	31.03	3.50	3.48
			7	10.36	31.05	3.47	3.43
			13	10.39	31.03	3.53	3.46
			20	10.38	31.06	3.44	3.61
5	Nov. 14	1317	0	8.55	30.72	3.64	2.90
			3	8.60	30.72	3.74	2.90
			7	8.68	30.72	3.74	3.13
			10	8.75	30.75	3.66	3.28
6	Nov. 14	1219	0	9.48	30.97	3.38	3.67
			16	9.41	31.00	3.27	3.65
			36	9.58	31.11	3.29	3.56
			56	9.75	31.09	3.25	3.70
7	Nov. 13	1219	0	9.41	30.62	3.35	3.67
			7	9.62	30.85	3.44	4.76
			13	10.05	31.26	3.46	3.43
			20	10.30	31.43	3.30	4.82
8	Nov. 16	1336	0	11.29	31.36	3.29	3.38
			26	11.29	31.35	3.29	3.12
			49	11.29	31.34	3.29	3.17
			72	11.95	31.34	3.21	3.09
9	Nov. 15	1357	0	12.55	31.22	3.59	3.30
			13	11.50	31.17	3.55	3.48
			26	10.40	31.19	3.49	3.22
			39	10.75	31.21	3.49	3.12
10	Nov. 14	1156	0	10.00	31.59	3.51	3.04
			7	10.00	31.58	3.40	3.14
			13	10.01	31.59	3.38	2.98
			20	10.25	31.58	3.39	3.14
11	Nov. 16	1416	0		31.76	3.28	2.70
			23		31.79	3.29	2.91
			46		31.79	3.24	2.67
			66		31.81	3.23	3.69
12	Nov. 16	1452	0		31.86	3.39	2.72
			7		31.84	3.44	2.91

Appendix table 4.--Cruise IV, November 11 to November 16, 1957--Con.

Station	Date	Time (Est.)	Depth	Temperature	Salinity	Oxygen	Total PO_4-P
			Feet	*°C*	‰	*Ml./l.*	*Mg.-at./l.*
			16		31.84	3.33	2.91
			26		31.85	3.29	2.93
13	Nov. 14	1125	0	10.68	32.08	3.32	2.36
			7	10.71	32.10	3.32	2.44
			20	10.85	32.09	3.27	2.33
			26	11.15	32.11	3.24	2.62
14	Nov. 11	0915	0	12.10	32.32	3.33	2.07
			33	12.20	32.31	3.24	2.10
			66	12.28	32.30	3.22	1.99
			98	12.60	32.30	3.15	2.17
15	Nov. 12	1040	0	11.19	32.36	3.29	1.86
			10	11.31	32.38	3.32	1.75
			16	11.40	32.40	3.24	1.94
			23	11.15	32.41	3.23	2.12
16	Nov. 12	1000	0	11.00	32.46	3.29	1.73
			20	11.37	32.48	3.26	1.78
			39	11.72		3.27	1.75
			56	12.20	32.47	3.24	1.78
17	Nov. 11	1040	0	12.36	32.56	3.34	1.52
			30	12.42	32.55	3.28	1.63
			59	12.42	32.55	3.22	1.65
			89	12.55	32.57	3.23	1.60
18	Nov. 15	1333	0	12.02	32.59	3.50	1.34
			13	12.18	32.58	3.51	1.41
			26	12.51	32.57	3.48	1.52
			39	13.28	32.58	3.42	1.70
19	Nov. 15	1315	0	9.80	31.66	3.57	3.28
			10	9.80	31.66	3.58	2.93
			20	9.83	31.67	3.54	2.96
			30	10.02	31.70	3.49	3.09

Appendix table 5.--Narragansett Marine Laboratory Pier Stations

Date	Time (Est.)	Depth	Temperature	Salinity	Oxygen	Total PO_4-P
1957		*Feet*	°*C*	‰	*Ml./l.*	*Mg.-at./l.*
Feb. 7		Sfc.	2.00	30.69	6.87	1.65
	1301	Bot.		31.59	6.61	2.33
Feb. 13		Sfc.	1.68	30.04	7.21	1.52
	1220	Bot.	1.69	30.04	7.21	1.52
Feb. 20		Sfc.	2.20	31.74	7.35	1.18
	1430	Bot.	2.22	31.68	7.16	1.28
Feb. 27		Sfc.	3.00	31.39	7.56	1.36
	0900	Bot.	2.82	31.59	7.54	1.33
Mar. 6		Sfc.	2.40	30.63	7.04	1.05
	0915	Bot.	2.80	31.56	6.87	2.22
Mar. 13		Sfc.	3.62	30.53	6.59	.97
	1030	Bot.	3.50	30.27	6.51	1.00
Mar. 22		Sfc.	4.83	30.06	6.51	1.21
	1430	Bot.	4.55	30.37	6.37	1.15
Mar. 27		Sfc.	5.42	29.68		1.41
	0920	Bot.	5.38	29.70		1.49
Apr. 3		Sfc.	5.82	30.83		1.20
	1300	Bot.	5.85	31.00		1.33
Apr. 10		Sfc.	5.59	30.08	6.18	1.31
	1515	Bot.	5.16	31.15	5.98	1.15
Apr. 17		Sfc.	5.63	31.36	5.97	1.28
	1115	Bot.	5.60	31.36	5.93	1.26
Apr. 24		Sfc.	10.45	27.79	5.93	1.23
	1030	Bot.	8.75	29.67	5.69	1.26
May 1		Sfc.	9.60	29.97	6.45	1.18
	0900	Bot.	7.82	30.78	6.30	2.20
May 8		Sfc.	10.70	30.20	6.57	1.59
	0845	Bot.	10.54	30.38	6.62	1.41
May 15		Sfc.	10.67	31.50	6.19	1.18
	1000	Bot.	10.39	31.57	6.33	1.31
May 23		Sfc.	12.25	30.62	5.67	1.65
	0730	Bot.	12.21	30.69	5.82	1.94
May 29		Sfc.	12.53	31.39	5.65	1.41
	0900	Bot.	12.49	31.47	5.83	2.86
Jun. 4		Sfc.	14.18	31.68	5.64	1.39
	1300	Bot.	13.82	31.70	5.79	1.49
June 11		Sfc.	16.67	31.32	5.40	1.73
	1200	Bot.	16.60	31.36	5.57	1.65
June 19		Sfc.	18.61	31.63	6.53	1.47
	1000	Bot.	16.92	31.90	5.97	1.41
June 26		Sfc.	20.42	31.73	5.94	2.07
	1330	Bot.	19.52	31.65	6.00	2.96

Appendix table 5.--Narragansett Marine Laboratory Pier Stations--Con.

Date	Time (Est.)	Depth	Temperature	Salinity	Oxygen	Total PO_4-P
		Feet	°C	‰	*Ml./l.*	*Mg.-at./l.*
Jul. 3		Sfc.	17.79	32.19	4.53	1.55
	1300	Bot.	17.43	32.20	4.70	1.57
Jul. 11		Sfc.	19.10	32.15	5.10	1.60
	0945	Bot.	18.21	32.17	5.16	1.65
Jul. 17		Sfc.	21.25	32.01	5.68	2.12
	1445	Bot.	21.03		5.60	2.07
Jul. 24		Sfc.	21.82	31.86	3.86	2.54
	1300	Bot.	21.75	31.86	4.13	2.59
Jul. 30		Sfc.	19.93	32.20	4.35	1.73
	0900	Bot.	19.70	32.21	4.32	1.81
Aug. 7		Sfc.	22.00	31.93	4.26	2.68
	1100	Bot.	21.87	32.02	4.28	2.18
Aug. 16		Sfc.	20.47	31.99	3.90	2.41
	0815	Bot.	20.49	32.01	4.04	2.36
Aug. 21		Sfc.	21.09	32.10	4.07	2.18
	1315	Bot.	20.62	32.10	4.95	2.25
Aug. 28		Sfc.	19.95	32.01	4.52	1.75
	1000	Bot.	19.91	32.01	4.51	1.81
Sep. 3		Sfc.	20.38	32.08	4.29	2.04
	1015	Bot.	19.97	32.17	3.99	1.91
Sep. 17		Sfc.	20.78	32.05	4.25	2.38
	1300	Bot.	20.02	32.24	4.34	1.78
Sep. 24		Sfc.	19.57	32.27		1.81
	1000	Bot.	19.55	32.28		1.81
Sep. 30		Sfc.	17.30	32.37	4.77	2.02
	0900	Bot.	17.23	32.40	5.67	1.99
Oct. 8		Sfc.	15.92	31.75	5.70	3.04
	1000	Bot.	15.94	31.78	5.66	2.75
Oct. 15		Sfc.	15.52	31.8	5.56	2.14
	1330	Bot.	15.40	31.9	5.81	2.04
Oct. 24		Sfc.	14.80	32.2	5.09	1.71
	0830	Bot.	14.80	32.3	5.07	1.65
Oct. 30		Sfc.	11.89	31.4	5.34	2.02
	0900	Bot.	11.88	31.7	5.22	2.25
Nov. 6		Sfc.	12.80	32.06	5.24	2.20
	0900	Bot.	12.86	32.08	5.29	2.36
Nov. 12		Sfc.	10.72	32.42	5.50	1.71
	0835	Bot.	10.90	32.46	5.37	1.71
Nov. 22		Sfc.	11.38	32.39	5.76	1.65
	0900	Bot.	11.32	32.41	5.64	1.60
Nov. 27		Sfc.	9.09	32.42	6.08	1.68
	1100	Bot.	9.19	32.44	6.00	1.68
Dec. 6		Sfc.	5.10	31.70	6.67	2.38
	0900	Bot.	5.06	31.70	6.65	2.44
Dec. 11		Sfc.	7.08	31.65	6.57	2.30
	1345	Bot.	7.18	31.71	6.47	2.41
Dec. 23		Sfc.	6.68	31.80	6.67	1.78
	1045	Bot.	6.40	31.82	6.44	1.75

Appendix table 5.--Narragansett Marine Laboratory Pier Stations--Con.

Date	Time (Est.)	Depth	Temperature	Salinity	Oxygen	Total PO_4-P
1958		*Feet*	°*C*	‰	*Ml./l.*	*Mg.-at./l.*
Jan. 2		Sfc.	5.62	30.63	6.70	2.04
	1045	Bot.	6.68	31.71	6.69	1.99
Jan. 8		Sfc.	4.68	31.36	6.74	2.28
	1100	Bot.	5.00	31.48	6.70	2.44
Jan. 15		Sfc.	2.21	29.68	7.57	1.91
	1000	Bot.	2.20	29.73	7.47	2.17
Jan. 22		Sfc.	3.00	30.51	7.31	1.91
	1400	Bot.	2.92	30.49	7.34	1.88
Jan. 29		Sfc.	3.70	27.47	7.75	2.17
	1400	Bot.	4.00	31.62	6.92	1.57

MS #1246

GPO 944-887

Created in 1849, the Department of the Interior—America's Department of Natural Resources—is concerned with the management, conservation, and development of the Nation's water, fish, wildlife, mineral, forest, and park and recreational resources. It also has major responsibilities for Indian and Territorial affairs.

As the Nation's principal conservation agency, the Department works to assure that nonrenewable resources are developed and used wisely, that park and recreational resources are conserved for the future, and that renewable resources make their full contribution to the progress, prosperity, and security of the United States—now and in the future.